2nd UGCT seminar
10 September 2015

Use of X-ray radiography and tomography to evaluate self-healing concrete

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Keywords: **concrete cracking, self-repair, X-rays, radiography, tomography**

ABSTRACT

Concrete is a frequently used construction material but it is susceptible to crack formation. As this reduces the durability and increases the maintenance costs of concrete structures, self-repair of cracks in concrete is a hot research topic. While concrete already has the natural ability to heal cracks to a limited extent, named autogenous crack healing, researchers try to improve this healing ability trough the addition of encapsulated healing agents, embedded bacteria, superabsorbent polymers,… which is called autonomous crack healing. In the Magnel Laboratory, research on self-healing of concrete is already going on for several years and the efficiency of some successful approaches has also been demonstrated by means of X-ray computed radiography and tomography.

In one approach, superabsorbent polymers (SAPs) were added to the concrete matrix in order to take up water entering the cracks, swell and block the cracks upon ingress of aggressive liquids. In addition, these SAPs should provide water for further hydration of unhydrated cement and for precipitation of calcium carbonate from leaching calcium hydroxide. By means of X-ray computed tomography (CT) it was clearly demonstrated that improved crack healing was obtained when these SAPs were provided in the matrix.

In another approach, calcium carbonate precipitating bacteria were embedded in the concrete matrix. When these bacteria make contact with nutrients upon crack formation, they wake up from their dormant state and start to produce calcium carbonate crystals closing the crack. CT-scanning of treated mortar samples showed that cracks tend to be closed more completely when bacteria are provided (Figure 1).

As it is the major goal to increase the durability of concrete and thus to reduce the entrance of aggressive agents, the crack sealing efficiency of another self-healing approach, consisting of encapsulated polyurethane, was investigated by means of X-ray radiography. It was shown that due to breakage of the embedded capsules upon crack formation and release of the encapsulated healing agent into the crack, water ingress into

the crack was prevented. Recently, X-ray radiography has also been used to demonstrate that due to the reduced ingress of water and aggressive agents into the crack, corrosion of reinforcement steel can be prevented. While for the unhealed reference samples pitting corrosion of the embedded steel was clearly visible on the radiographs, for samples with autonomously healed cracks corrosion initiation was clearly prevented (Figure 2).

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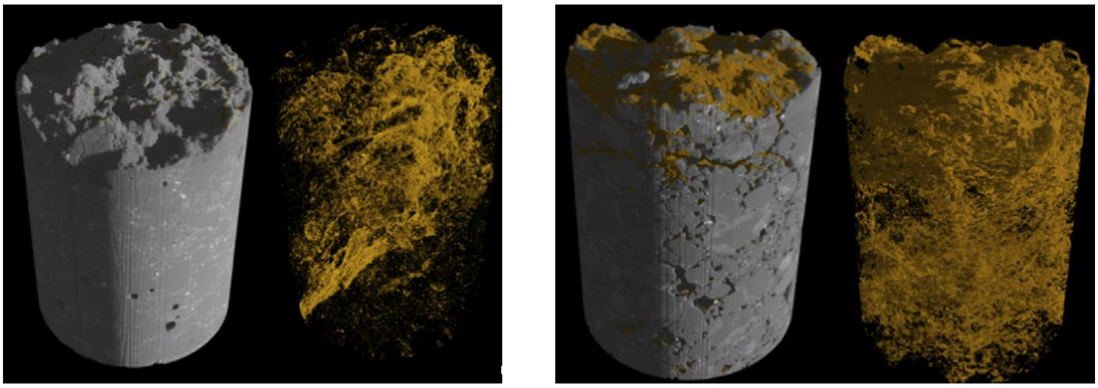

Figure 1: Enhanced calcium carbonate precipitation inside the crack due to the addition of bacteria to the concrete matrix (Wang et al., 2014)

UNHEALED CRACK AUTONOMOUSLY HEALED CRACK

Figure 2: Prevention against pitting corrosion, by self-healing of the crack through release of encapsulated polyurethane, after 30 hours exposure to an acceleration corrosion test

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